

CLEAR-AIR TURBULENCE AND METHODS OF DETECTION

Second Semi-Annual Report under

Grant NGR 44-012-048

National Aeronautics and Space Administration

by

Electrical Engineering Research Laboratory

The University of Texas

March 31, 1967

RESEARCH OBJECTIVES

This is the second semi-annual report submitted in accordance with the requirements of NASA Grant NGR 44-012-048 and covers the period from October 1, 1966 through March 31, 1967.

The research objectives of the grant are to study the nature of clear air turbulence and methods for its detection. The various phases of this research are as follows:

- 1. A review of available literature on the situations under which CAT occurs and the nature of the turbulent energy spectra observed or postulated.**
- 2. An evaluation of the probable refractive index structure associated with CAT from the turbulence studies in 1.**
- 3. A theoretical study of backscattering cross-section associated with the CAT refractive index structure discussed in 2 and with refractive index variations in general.**
- 4. The measurement of refractive index differences at low levels and the comparison of these data with theoretical predictions.**
- 5. Evaluation of the possibility of radar return from inhomogeneities in the atmosphere.**

STATUS ON SEPTEMBER 30, 1966

During the first six months of the grant, the emphasis was put on the first three items in the section above. Dr. J. J. Stephens and Dr. E. R. Reiter describe the results of the study of the nature and occurrence of CAT in the following report:

J. J. Stephens and E. R. Reiter - Estimating Refractive Index Spectra in Regions of Clear Air Turbulence - Report P-12, Antennas and Propagation Laboratory, The University of Texas, 5 October, 1966.

This phase of the research has been completed and the emphasis shifted to evaluating radar methods of detection of CAT and to understanding the nature of refractive index difference fluctuations as they influence the radar return from turbulent regions.

At the beginning of the period covered by the present reporting, a theoretical study of factors involved in this radar return was well under way by Dr. Bob M. Fannin and Mr. Allan B. Plunkett.

The measurement of the detailed structure of refractive index differences was also well under way and the analysis of these data has been a major part of the research effort in the current period.

RESEARCH ACTIVITIES OCTOBER 1, 1966 - MARCH 31, 1967

During the last six months, the research effort under the grant has been directed toward the objectives of items 3, 4 and 5 in the first paragraph as follows:

1. Radar Return from Turbulence.

The first part of the radar return study was conducted by Dr. B. M. Fannin. He used currently available models of the over-all physical properties of CAT to evaluate the possibility of radar return from regions of clear air turbulence.

Most of the emphasis was concentrated on systems whose ultimate goal is to devise instrumentation to be placed on jet transport planes to give warning of, and detailed information about regions of CAT in the line of flight. The results of this study were described in the following report:

B. M. Fannin - Remote Detection of Clear Air Turbulence - Part I: Pulsed Microwave Radars - Report P-13, Antennas and Propagation Division, Electrical Engineering Research Laboratory, The University of Texas, 1 November 1966.

The study of radar return from atmosphere turbulence is being continued by Allan B. Plunkett and Dr. B. M. Fannin. This phase of the study is concentrating on the choice of radar parameters necessary for the optimum return.

The results of this study will be used by Mr. Plunkett for his Master's thesis.

2. Refractive Index Structure Study.

In order to obtain a better understanding of the part played by refractive index variations in radar reflections, a measurement program of refractive index differences was carried out.

Four Deam type refractometers were mounted on top of an 85 meter tower at Balcones Research Center of The University of Texas. Difference in index of refraction as well as the index changes at a single unit were recorded.

Data analysis of these measurements has been a major part of the research program during the past six months. Several remarkable results have come out of this study. From probability distribution of the fluctuations, a dual characteristic of the index fluctuations has become apparent. Superimposed on the continuum of variations are spikes of a very sharp nature. These spikes seem to play a major part in the structure function which controls the radar return. It is proposed that these spikes may be explained by a small enhancement in the water vapor concentration in a region with dimension of a few meters.

Studies of the filter function imposed by using refractive index differences indicates that coherence in structure is maintained for a cycle when condition of constant wind speed exists. When more variable situations occur, a random type variation proposed by Tatarski is approximately followed.

3. Proposed Papers.

The results of the preceding study are proposed for publication in two technical journals as follows:

A. W. Straiton, A. P. Deam and J. L. Dodd - Amplitude Distributions of Refractive Index Differences - proposed for Journal of Geophysical Research.

A. W. Straiton, A. P. Deam and J. L. Dodd - Analysis of Spectra of Atmospheric Refractive Index Differences - proposed for Radio Science and for Spring URSI Meeting in Ottawa.

Removed

Copies of these papers are made a part of this report. Details of the results will not be repeated here.

NO COST EXTENSION

Early in the period covered by this report, discussions were held with personnel at the Electronics Research Center of NASA concerning continuing research effort under this grant. In view of the fact that our capabilities and interest indicate that we may contribute more to radio wave studies by shifting from those associated with clear air turbulence alone to those concerned with transmission through the entire atmosphere, some re-orientation of the activities under the present grant seemed desirable. It was therefore recommended by letter of 9 January 1967 that the period of the grant be extended through November 30, 1967 at no additional cost.

Further, it was understood that there would be no additional fiscal 1967 funds available for the grant extension. In view of these facts, it appeared desirable to concentrate on those phases of the research which could be completed by the end of November. The proposed areas of extension are given in the next section.

By letter of January 24, 1967, extension of the grant period through November 30, 1967 was approved by the Office of Grants and Research Contracts of NASA.

RESEARCH CONTINUATION

The research effort after April 1, 1967 will be continued along three lines as follows:

1. As previously mentioned, Mr. Allan B. Plunkett is conducting a study of the parameters involved in radar system design for optimum detection of atmosphere turbulence. This study will be used by Mr. Plunkett for his Master's thesis research with the degree to be awarded in June or August, 1967.
2. The analysis of the refractive index difference data will continue with the measurement results compared to various theoretical models. Mr. Dodd is well along with this study which will be used for his Ph. D. dissertation. His degree will probably be awarded in June 1967, but no later than August 1967.
3. The third phase involves the measurement of radio refractive index on top of Mt. Evans during the summer of 1967. There is no present information available on the structure function of refractive index difference at such high altitudes. It is believed that these measurements will be very valuable in understanding of the process of clear air turbulence detection by radar.